SPACE-TIME CURVATURE AROUND NUCLEONS

Petar K. Anastasovski and David B. Hamilton

Abstract

Einstein's equation for calculating the angle of deflection of a beam of light passing near the sun is applied to proton analysis to describe space-time curvature and its effects around the nucleons. The gravitational constant is defined and determined by the principles of the theory for Superluminal Relativity, **SLR**. Correlation between the mass of the Sun and that of the proton with angles of light deflections to the sun and near the proton is established. This correlation shows that the observed deflection of light passing near the Sun during its eclipse is not only the verification and validity of General Relativity Theory, GRT, for stellar dimensions and space, but also for the nucleon' s dimensions and space, and more importantly, for nuclear structures. Hence, this is also verification of the validity of the principles for the theory of SLR.

1. Introduction

1.1 The General Theory of Relativity

In 1916, Einstein published his work "The Fundamentals of General Relativity" [1], which was 11 years after he had published his theory of Special Relativity (SRT) [2], [3]. Later in 1954, he published work to explain the differences and connections between special and General relativity [4]. In this work he gives the exact formulation of General relativity with the following two postulates.

1. The laws of physics must be of a nature that they applied to all reference systems, in any kind motion, relative to the mass distribution of universe.
2. The principal equivalence: all bodies at the same place in a gravitational field experience the same acceleration. Note: recent evidence indicates that there is a nonlinear relationship, however we are too close and the relative mass that we can test too small for us to observe.

Both postulates are adopted in SLR, which will be used here [5].

According to Einstein, instead of a reference body, the Gaussian coordinate system should be used. Einstein states that "To the fundamental idea of the principal of GRT corresponds the next statement all Gaussian accord systems are equally valid for formulations of the general laws of nature" [4]. Furthermore, Einstein states "SRT is valid for Gallian ranges, which means for ones where a gravitational field is absent. The Gallian reference body is used as a reference body, that is the same rigid body with such a chosen state of motion relative to it, so that the Gallian postulates for uniform straight-line motion relative to it, so that the Gallian postulates for uniform, straight-line motion of an individual material, is valid. However, in gravitational fields there are no rigid bodies with Euclidian properties; the notion of rigid reference body's has no application in GRT. The gravitational fields influence the work of clocks in such a way that physical definition of time strictly by the clock is no longer so evident as in SRT [4]. This is the main reason why the Gaussian four-dimensional system is more convenient for GRT, and consequently, the laws of nature should not be dependent on the chosen frame of reference. **This is exactly what is proven by the theory of SLR [5]**.

The first postulate of GRT, and Einstein's explanation of it, is very important to the theory of SLR.

The second principal of GRT, the principal of equivalence, explains that there is a difference between the two properties of mass, gravity and inertia. Gravitational attraction acts between masses, pulling them together, while the inertial property resists acceleration. To designate these two attributes we use the subscripts g and i, and write:

Gravitational property:	$F_g = m_g\, g$	(1)
Inertial property:	$F_i = m_i\, a$	(2)

The value for the gravitational constant, G, was chosen to make the magnitudes of mg and mi numerically equal. Regardless of how G is chosen, however, the strict equality of the gravitational element and the inertial element of mass has been measured in extremely high degree. Thus, it appears that gravitational mass and inertial mass may indeed be exactly equal [6].

As a contrast to the SRT concept that the presence of any kind of bodies does not influence the properties of space and time, GRT demands that bodies influence space-time and one another. Reference [5] elaborates on space-time curvature in GRT and in SLR.

In particular, the prediction by and validation of GRT that a beam of light will bend in the presence of a gravitational field is of interest here. The velocity of light in a gravitational field is [1] is given below.

$$c' \approx c\left(1 - \frac{2Gm}{r\,c^2}\right) \tag{3}$$

where,

$$G = 6.67\cdot 10^{-11}\ Nm^2\, kg^{-2} \tag{4}$$

is the gravitational constant, m is the mass of the Sun, r is the shortest distance between the light' s path and the center of the sun and c is velocity of light in vacuum. The deflection of light from its direction propagation is given by reference [1] as,

$$\alpha_s = \frac{4Gm}{rc^2} \tag{5}$$

In this case, Einstein computed that light from certain star passing close to surface of the sun would be deflected by the sun's local space-time curvature by a factor of 1. 7 5 min. of arc.

$$\alpha_s = 1.7'' \tag{6}$$

The effect of space-time curvature near massive of bodies was verified during an eclipse of the sun in 1919, when the following values were measured [4], [7],

$$\alpha_s = 0.8'' \tag{7}$$

and

$$\alpha_s = 1.8'' \tag{8}$$

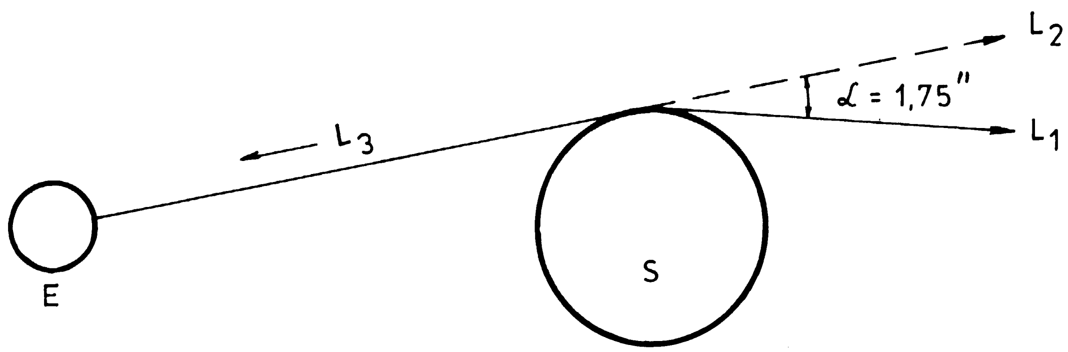

Figure 1

Depiction of Starlight deflected as it passes very near the sun, where E is the Earth, S is the Sun, Alpha equal 1.75 " is the angle of the light's deflection, L. one is the actual direction to the star, L. 2 is the apparent direction to the star, and L3 is the deflected path to Earth after the Starlight's interaction with the Sun' s local space-time curvature.

Figure 1 shows the deflected path of Starlight passing very close to surface of the sun. According to Einstein's explanation, half of this deflection is caused by the mass interaction between the Sun and the passing photons of light, while the other half of it by the local space-time curvature [4], [7], [8].

1.2 Quantum Gravity[1]

Quantization of the gravitational field is applied in the following analysis requiring a brief description of quantum gravity. There is incompatibility between Gravity and SRT. Misner, Thorne and Wheeler [9] note that the

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[1] *) It is worth mentioning that angle of light's deflection of 1,75" is computed for r = 1,21 $\cdot 10^7$ m, while the radius of the Sun is considered to be r = 6, 95 $\cdot 10^8$ m.

**) There are two figures that appear in the literature, 1,75" and 1,7".

question of SRT constantly assumes the absence of gravitational fields, which makes SRT contrary to our reality. Gravity is ignored in SRT because of the difficulties that gravitational fields presented on the foundations of SRT at the time of its development. After meeting these difficulties, one can appreciate the curved space-time methods that Einstein introduced to overcome them [10].

According to Hawking and Rocek [11] GRT has its own shortcomings. They state that the Newtonian theory of gravity is very successful in predicting planetary and stellar orbits, but because it implied that gravitational effects propagate with instant velocity, it was incompatible with the local validity of SRT. This difficulty was overcome in 1916 with the formulation of GRT in which the gravitational field was represented using curved space-time. Since that time, the predictions of GRT have been found in excellent agreement with observations. However, GRT is incomplete at least two ways:

(1) it doesn't relate gravity to interaction and matter fields that occur in physical theories and
(2) is a purely classical theory, whereas all other fields seem to be quantized [10], [11].

The necessity to quantize gravitational fields has become more urgent as the inevitable result of GRT's classical treatment is space-time singularities [11]. Many theories have been developed to show how to quantize the gravitational field, but to briefly show "the necessity to quantize gravitational field" we will consider how Unrich [12] tackles the problem. The fundamental equation of GRT is:

$$G_{\mu\nu} = 8\pi\left\langle T_{\mu\nu}\right\rangle \tag{9}$$

Choosing units so that G equals h equals c equals 1. The left-hand side of this equation represents the geometry of space-time, while the right hand side is dependent on the rest of the matter the universe. The left-hand side is "classical" and an ordinary function of space-time points, while the right hand side is a quantity, which depends on quantum operators. Thus the two sides are different and cannot be set equal to one another [12]. However, Isham [13] prefers to write equation (9) in the form:

$$G_{\mu\nu} = T_{\mu\nu}\left(matter, g\right) \tag{10}$$

However, Isham found this treatment also to be inadequate and presented the following modification:

$$G_{\mu\nu} = \left\langle T_{\mu\nu}\left(matter, g\right)\right\rangle \tag{11}$$

Here, the <> denotes the expectation value of the quantize system in some suitable state [10], [13].

So far both Unrich and Isham have the same approach to the quantization of the gravitational field, which leads to the conclusion that the "gravitational field should be introduced as a dynamic variable rather than as a fixed background" [10], [12], [13].

Instead of the symbol <>, which denotes only that "the expectation value of the quantized system in some suitable state" can be obtained [13], we introduce using reference [5], that quantization of the gravity of a proton-neutron system is achieved by obtaining numerical values for gravitational magnitude G_n'. By this modification of G_n', "gravitational field is now introduced as a dynamic variable rather than as a fixed background", in agreement with Unrich [13].

The concept that quantization of Gravity can be achieved if the gravitational field is introduced as a dynamic variable [12], [13], is applied in Quantum Mass Theory (QMT) [10] and SLR [5]. Using the references to QMT and SLR, space can be divided in to three generalized ranges with different vacuum structures.

1. The range determined by $r < \lambda_{ce}$, where the close proximity of the nucleons and their space-time curvature effect the local gravitational attractive force making $G'_n = f(n)$valid.
2. The range determined by $Qr_0 > r > \lambda_{ce}$, where anti-gravitational, or repulsive force develops due to the influence of the nucleons with the electrons making G' valid.
3. The range determined by $r > Qr_0$, returns us to the familiar form of the gravitational attractive force that exists between atoms and molecules. This range is beyond the effect of local space-time curvature on G caused by the nucleons.

Where,

r is the distance from the center of the observed mass,
λ_{ce} is the Compton wavelength for the electron,
r_0 is the Bohr radius for the hydrogen atom, and
Q is an integer larger than n, where n=5 is the quantum number of the last electron shell.

A primary assumption in QMT [10] is that a antigravitational force exists that is equal to the coulomb's attractive force.

$$F_m = F_e \tag{12}$$

F_m is antigravitational force, and F_e is Coulomb's attractive force, between electron and proton, when they are on the ground energy level, for n = 1 in hydrogen atom.

The Equation (12) yields*),

$$G' = 1.49 \cdot 10^{29}\ Nm^2kg^{-2} \tag{13}$$

In the presented analyses, curved-space-time method is used to support the concept for new comprehension of nuclear forces and structures offered in Ref. [5].

*) In the Ref.[10] in p. 23, Eq (55), erronous value of G' is given, which may confuse the readers.

2. ENERGY LEVELS IN THE SUPERLUMINAL FRAME OF REFERENCE, WHERE $V > c$.

According to the second assumption of the Theory for Superluminal Relativity [5], the vacuum properties of space determined by the boundaries λ_{ce} and λ_{cp}, influence the properties of the nucleus, and consequently influence nuclear reactions as well, where λ_{ce} is electron Compton wavelength, and, λ_{cp} is proton Compton wavelength. [5]

The results of the analysis presented in Table 1, show that this space can be divided into five energy levels, which correspond to the five values of the gravitational constant G_n', determined by quantum number n, and the five distances r. These energy levels are determined for a proton-neutron system. [5]

In Table 1, energy levels for two distances $r_5 = 6.36 \cdot 10^{-16}$ m and $r_6 = 1.417 \cdot 10^{-16}$ m, which are under the limit $\lambda_{cp,}$ are presented. This table covers seven energy levels altogether. In Table 1 and positions of λ_{ce} and λ_{cp}, the proton radius r_p, and the proton-neutron distance r_d in the deuteron nucleus are also presented.

The values for G'_5 and G'_6 are computed for distances less than the radius of the proton. The reason is that each nucleus and consequently each particle has *surface thickness*. We shall cite deShalit and Feshbach here: Because the nuclear density, and also particle density, does not change abruptly from its nominal value to zero outside the nucleus and particle, there is a finite region called the *nuclear surface* (the *particle's surface*). The width of that region labeled with s is defined to be distance over which the density drops from 0.9 of its value at $r = 0$ to 0.1 of that value. Empirically s is a constant [14], [15]

$$s \approx 2.4 \ fm \tag{14}$$

For many nuclei s is approximately,

$$s = 0.2 \, r \tag{15}$$

where r is the nucleus' or particle's radius. Thus, for a proton which has the radius,

$$r = 8.13 \cdot 10^{-16} \ m \tag{16}$$

the surface thickness will be,

$$s = 1.742 \cdot 10^{-16} \ m \tag{17}$$

and the difference is,

$$r - s = 6.38 \cdot 10^{-16} \ m \tag{18}$$

T a b l e 1

Principle quantum number n	G_n' [N m^2 kg^{-2}]	Sub-quantum number *l*	r (m)	α_k
			a) $\lambda_{ce}= 2.4262 \cdot 10^{-12}$	
0	$G' = 1.49 \cdot 10^{29}$	0	$r' = 1.1688 \cdot 10^{-12}$	34.11"
		0.5	$r_{0.5} = 5.513 \cdot 10^{-13}$	16.08"
1	$G_1' = 3.314 \cdot 10^{28}$	0	$r_1 = 2.6 \cdot 10^{-13}$	34.11"
		0.7	$r_{1.7} = 9.08 \cdot 10^{-14}$	21.73"
2	$G_2' = 7.373 \cdot 10^{27}$	0	$r_2 = 5.78 \cdot 10^{-14}$	34.11"
3	$G_3' = 1.64 \cdot 10^{27}$	0	$r_3 = 1.28 \cdot 10^{-14}$	34.11"
	$G_d' = 4.6 \cdot 10^{26}$	0.7	$r_{3.7} = 4.494 \cdot 10^{-15}$	21.73"
			b) $r_d = 4.0 \cdot 10^{-15}$	
4	$G_4' = 3.64 \cdot 10^{26}$	0	$r_4 = 2.86 \cdot 10^{-15}$	34.11"
		0.5	$r_{4.5} = 1.35 \cdot 10^{-15}$	16.08"
			c) $\lambda_{cp} = 1.32 \cdot 10^{-15}$	
			d) $r_p = 8.13 \cdot 10^{-16}$	
5	$G_5' = 8.12 \cdot 10^{25}$	0	$r_5 = 6.37 \cdot 10^{-16}$	34.11"
6	$G_6' = 1.80 \cdot 10^{25}$	0	$r_6 = 1.41 \cdot 10^{-16}$	34.11"

a) electron Compton wavelength;
b) distance between nucleons in deuteron nucleus;
c) proton Compton wavelength;
d) proton radius.

Hence, we have computed G'_5 and G'_6 for distances, which go slightly beneath the surface thickness of the proton.

As is shown in Table 1, when the neutron is approaching the proton, only by the attractive force because of the presence of the gravitational field between masses of these two particles, the attractive force will depend on the gravitational constant for a certain distance. For instance, when the neutron and the proton reach the distance $r_d = 4.0 \cdot 10^{-15}$ *m*, the gravitational constant will be $G_d' = 4.6 \cdot 10^{26}$ $N\, m^2 kg^{-2}$, and the binding energy will be 2.22 MeV. Then this proton-neutron system creates deuteron nucleus.

The values of the gravitational constants are determined by the expression [5],

$$G'_n = \frac{G'}{(4.495)^n} \tag{19}$$

where n is an integer from 1 to 6, and could be considered as the principal quantum number for this system. The latter equation can be expressed by the fine structure constant α,

$$G'_n \approx \frac{G'}{\left(\frac{1}{30\alpha}\right)^n} \tag{20}$$

where,

$$G' = 1.49 \cdot 10^{29}\ Nm^2 kg^{-2} \tag{21}$$

The value of G' is determined in the Ref. [10]. The fine structure constant is,

$$\alpha = \frac{2\pi e}{hc} \tag{22}$$

which describes the coupling of any elementary particle carrying the elementary charge e to the electromagnetic field, where h is the Planck's constant.

Hence, we may introduce **the fine structure constant for nuclear systems**, in this case for the proton-neutron system. This constant could be considered as a magnitude, which expresses properties of the proton-neutron system and the surrounding space. This magnitude is,

$$\alpha' = \frac{1}{30\alpha} \tag{23}$$

the **nuclear fine structure constant,** which determines the structure of the vacuum as a function of the principal quantum number n. It determines the energy levels in the space determined by λ_{ce} and λ_{cp} between the proton and the neutron.

Thus, Equation (19) becomes,

$$G'_n \approx \frac{G'}{(\alpha')^n} \tag{24}$$

Gravitational constant G'_n and its values given in Table 1 suggest the possibility for existence of structure of the vacuum connected with gravitational properties of the particles.

The distances r_n which correspond to certain gravitational constants G'_n are determined by the equation,

$$r_n = \frac{r'}{(4.495)^n} \tag{25}$$

or,

$$r_n = \frac{r'}{(\alpha')^n} \tag{26}$$

3. MODIFIED EINSTEIN'S EQUATION FOR DEFLECTION OF THE LIGHT NEAR SUN APPLIED FOR PROTON

The Einstein's equation for deflection of light near the Sun, is modified for nucleon, in our case for proton, when the gravitational constant

$$G = 6{,}67 \cdot 10^{-11}\ \mathrm{Nm^2kg^{-2}}$$

in the Eq. (5) is substituted, according to the Eq. (24), by the gravitational constant,

$$G'_n \approx \frac{G'}{(\alpha')^n}$$

The values of this constant for quantum numbers from n = 0 to n = 6 are presented in Table 1. The Eq. (5) becomes,

$$\alpha_k = \frac{4G'_n m_p}{r_k c^2} \tag{27}$$

where α_k is deflection's angle of the light near the proton, for closest distance of light's path from the center of the proton, which corresponds to total quantum number k; m_p is proton mass; c is velocity of light in vacuum; r_k is the shortest distance between the light's path and the center of the proton, determined by the expression:

$$r_k = \frac{r'}{(4.495)^k} \tag{28}$$

where,

$$k = n + l \tag{29}$$

is the total quantum number, n is principle quantum number and *l* is sub-quantum number with values: 0; 0.1; 0.2; 0.3; ...... 0.8; 0.9.

Before we use the Eq. (27) to determine deflection angles of the light near the proton in the range λ_{ce} - λ_{cp}, it is necessary to find out how this equation can be applied for distances

$$r > \lambda_{ce}$$

where gravitational constant G' is valid.

For the metric space determined by the distances

$$Qr_0 > r_p > \lambda_{ce}$$

gravitational constant is,

$$G' = 1.49 \cdot 10^{29} \ Nm^2 kg^{-2}$$

thus, the Eq. (27) becomes,

$$\alpha_p = \frac{4G' \ m_p}{r_p c^2} \qquad (30)$$

where r_p is the shortest distance of the light's path, from the center of the proton in the range determened above.

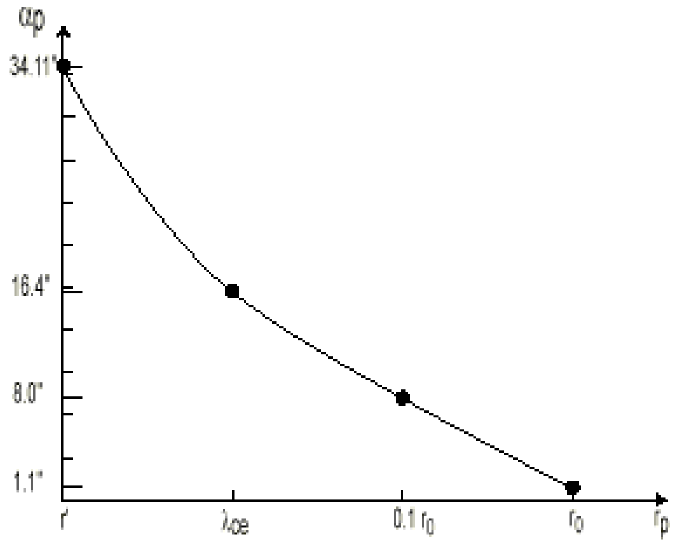


Fig. 2 Presentation of the function $\alpha_p = f(r_p)$, for $r_p > r' = 1.1688 \ 10^{-13}$m.

Fig. 2 shows the curve of the ligh's deflection angles for characteristic distances from the center of the proton: r', λ_{ce}, $0.1r_0$ and r_0, where r_0 is the Bohr radius in the hydrogen atom. The curve shows that for distance r_0 the angle of light deflection is approaching zero. It is worth mentioning that r_0 here has a new meaning. **Bohr radius in hydrogen atom is acctually the distance from the center of the proton where the curved space-time ends.** We shall return back to this question in the next subsection.

Now, we will continue the analyses by applying the Eq.(27) in the range λ_{ce} - λ_{cp}, where vacuum properties are quantized and gravitational constant is turning into a gravitational magnitude with values determined by the principle quantum number n.

For l = 0, k = n = 0, the Eq.(27) becomes,

$$\alpha_0 = \frac{4G'\ m_p}{r'\ c^2} \tag{31}$$

The Table 1 shows that, α_k, for the values of k, from n = 0 to n = 6, with *l* = 0, has the same value, i.e.,

$$\alpha_k = \alpha_0 = 34.11'' \tag{32}$$

The ratio between this angle of light's deflection α_k near the surface of the proton and the angle of light's deflection near the surface of the Sun, α_s is,

$$K_\alpha = \frac{\alpha_k}{\alpha_s} = 20.064 \tag{33}$$

The Eq.(33) shows that light, passing near the proton's surface, has angle of deflection 20 times the angle of deflection of the light passing near the Sun.

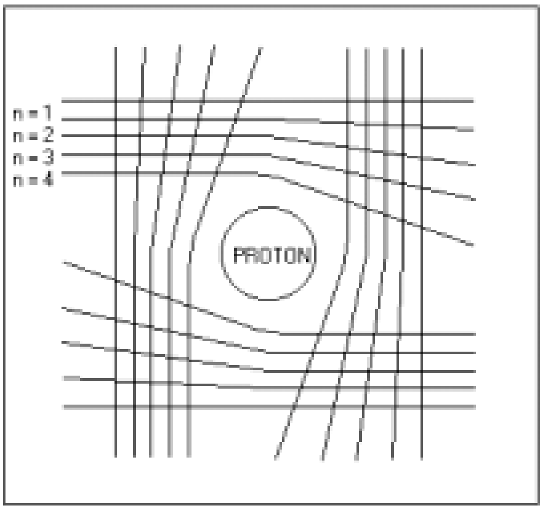
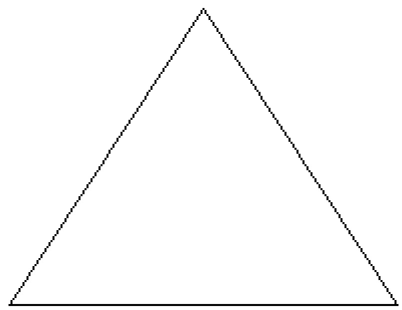


Fig. 3

Fig. 3 shows, out of the scale of proportion, light's deflections near the surface of proton for distances determined by the quantum numbers, from n = 1 to n = 4. These are the shortest distances between the light's path and the center of the proton. This figure shows the **space-time curvature around the proton.**



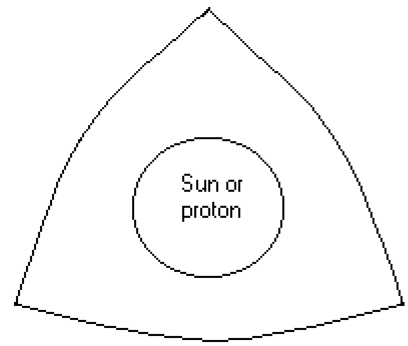


Fig. 4 Equilateral triangle composed of light's rays in Euclidean space, free from the gravitational influence.

Fig. 5 Triangle composed of light's rays, bent by space-time curvature around the Sun and the proton, without keeping the scale of proportion.

Theory of General Relativity can not apply Euclidean geometry, thus, the equilateral triangle from the Fig. 4, turns into the form presented on the Fig. 5, when gravitational field is present and when the Theory of General Relativity is applied. Fig. 5 shows triangle composed of light's rays as a result of the space-time curvature around the Sun and the proton, without keeping the scale of proportion.

Determining the angle of light's deflection near the proton could be considered as a new method for determining the vacuum properties and presence of mass, which could be experimentally verified, what will be discussed later on in this paper. By using this method we shall determine the angles of the light's deflection near the proton, in the metric space determined by the total quantum number k. Figure 6 shows the curve,

$$\alpha_k = f(k) \tag{34}$$

Fig. 6a is 3D presentation of the Fig. 6. The sphere at the center of the 3D diagram represents the proton out of the scale of proportion.

The curve in the Fig. 6 shows the periodic nature of the curved space-time around a proton. **It is important to emphasize that the gravitational magnitude G'_n is valid for distances which correspond to the quantum numbers from k = n to k = (n-1) + *l*, where $l \neq 0$.**

By using this method it will be shown that the curved space-time expresses distribution of the intrinsic vacuum energy [5].

It is possible to choose any particular distance between the light's path at the center of the proton, in the range of λ_{ce} - λ_{cp}, in order to explore the energy distribution in the curved space-time. The light, that is, individual photons can be used as a kind of probe for detecting the energy distribution in the curved space-time. Besides the photons in the visible range, there can be used X and gamma rays.

In the Table 1 are presented the values for α_k for distances which correspond to,

$$k = n$$

and for distances corresponding to,

$$k = n + l$$

when G'_n is valid for distances corresponding to k = n and k = (n-1) + l, when $l \neq 0$.

Fig.7 presents the values of α_k for chosen distances and presents the curve which is formed by extreme values of α_k. The Fig.7a is a 3D presentation of periodical function $\alpha_k = f(k)$ from the Fig.7.

The curve presented in the Fig.7 should be considered periodic because it represents the vacuum properties of non-Euclidean space-
time. Here the axes of the coordinate system are straight lines, while in non-Euclidean space-time there are no straight lines. This figure actually shows that space-time curvature around a proton has more complicated nature than it is graphically presented on the Figs. 3 and 5. This is because it is not possible non-Euclidean figures to be presented by Euclidean geometry, which is evident in Figs. 6 and 7. Such graphic presentations have to be taken conditionally.

The wavelength of the function presented in Fig.7 is,

$$\lambda_{st} = 5.499 \cdot 10^{-4}\, nm \qquad (35)$$

Quantum of the energy associated with this wavelength is ,

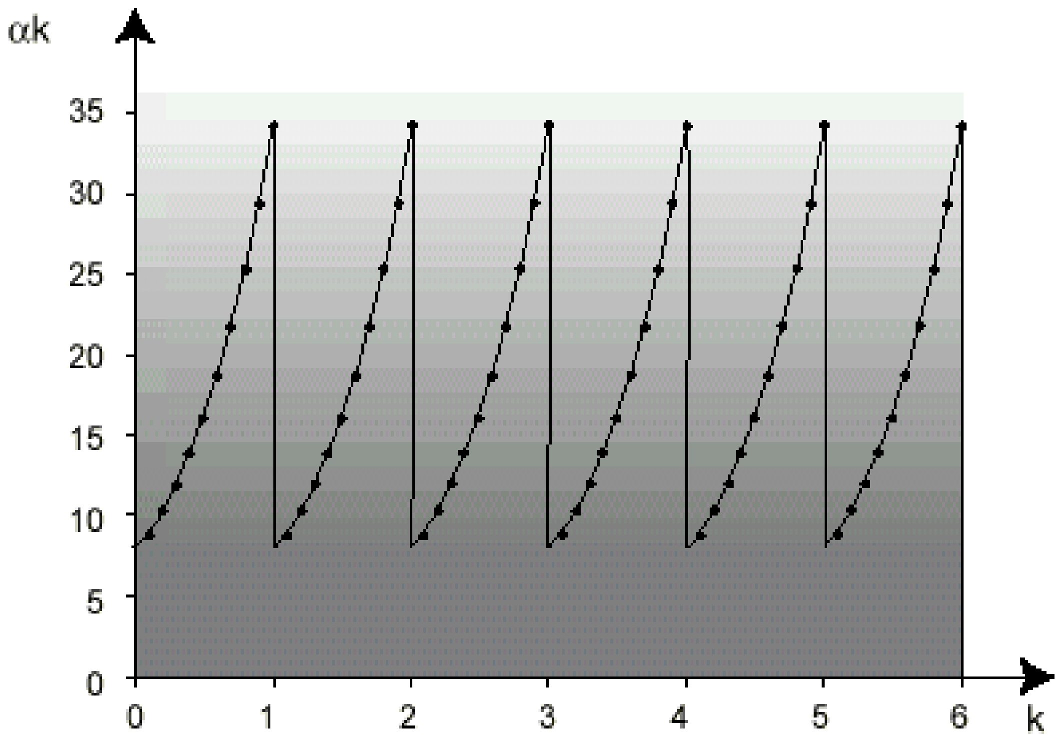
$$E_{st} = 2.254\ MeV \qquad (36)$$

The binding energy of deuteron nucleus is,

$$E_d = 2.23\, MeV \qquad (37)$$

The accordance between these two values is 1.07%.

This computation shows that space-time curvature around proton is characterized by the wavelength λ_{st} and energy E_{st}.



<u>Fig.6</u> Presentation of the curve $\alpha_k = f(k)$.

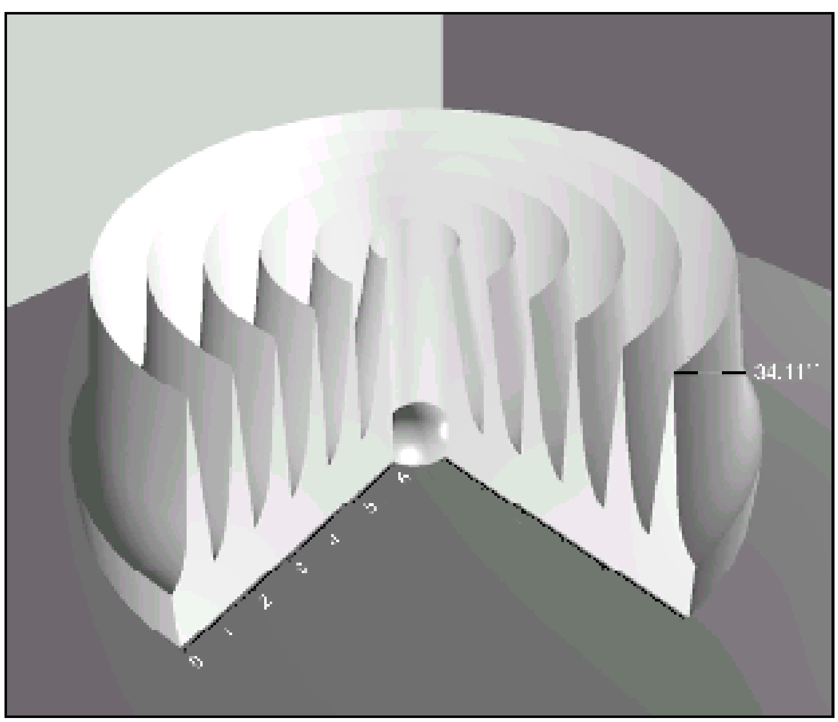


Fig.6a 3D presentation of the Fig.6. The sphere at the center of the 3D diagram represents the proton in out of scale proportion.

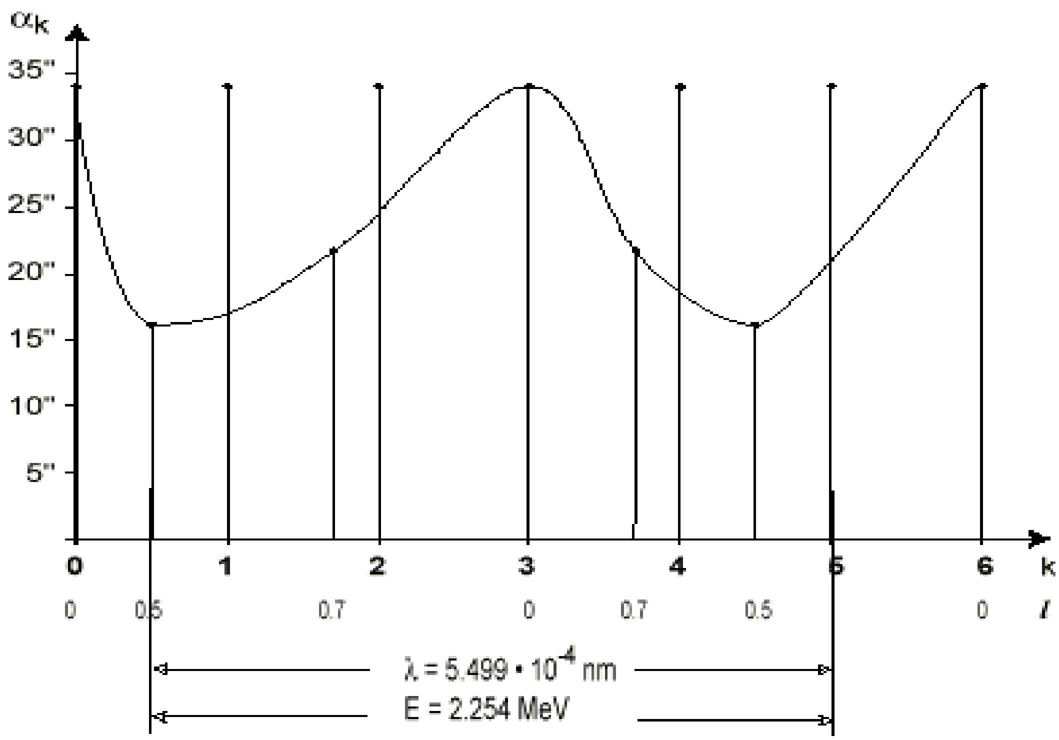


Fig.7 Presentation of $\alpha_k = f(k)$ for chosen distances determined by *l*.

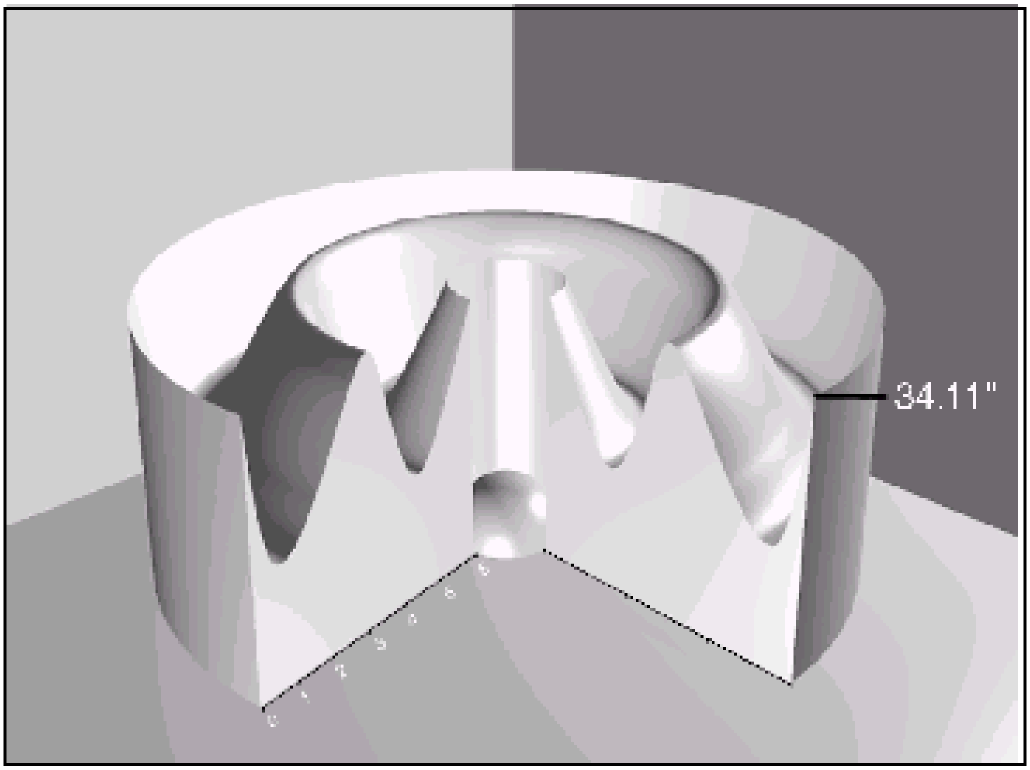


Fig.7a 3D presentation of the periodic function $\alpha_k = f(k)$ from the Fig.7. The sphere at the center of the 3D diagram represents the proton out of the scale of proportion.

The region of space-time curvature around proton, which is covered by this computation is determined by the total quantum numbers, from $k = 0$ to $k = 6$. The result shows that this region has potential energy of the order of MeV. The proton-neutron system, which creates deuteron nucleus is in the energy level determined by the total quantum number $k = 3$ and the binding energy of this nucleus is 2.23 MeV.

The above analysis shows that the value of the deuteron nucleus' binding energy computed by the magnitudes, which characterize the space-time curvature around proton, has excellent accordance with experimentally observed value. Therefore, it is justified to consider these results as experimentally verified, what proves that the space-time curvature around proton exists.

The structure of the vacuum, determined by the gravitational field around the Sun, depends on the constellation of the planets and the Sun itself, which form the solar system. The main magnitude, which expresses this gravitational field, is the gravitational constant G. In the same manner, the vacuum structure determined by the gravitational fields around the proton depends on the proton itself and on the particles around it. In our case the vacuum structure was determined for two-particle system, that is, proton-neutron system. When the distance between these two nucleons is $r_d = 4.0 \cdot 10^{-15}$m, they form the deuteron nucleus. The space between these two particles in the region λ_{ce} - λ_{cp} has vacuum structure determined by the gravitational magnitude G'_n.

The ratio between gravitational constants G'_n and G, yields very interesting equation,

$$\frac{G'_n}{G} = K_\alpha \frac{m \cdot r_{pn}}{m_p \cdot r} \tag{38}$$

In this equation gravitational magnitudes G'_n and G, which represent corresponding vacuum structures, are connected with masses of the Sun (m) and the proton (m_p), and distances, where phenomena of light deflections are taking place. The constant, which establishes this connection, is $K_{\alpha,}$ the ratio of angles of deflections of the lights passing near the surfaces of the proton and the Sun, respectively.

3.1 EXTRACTION OF ENERGY FROM VACUUM

The results of the analysis of the curved space-time around a proton show that there is an energy distribution around a proton as a result of vacuum structure and presence of the mass in that vacuum.

Let us consider the possibility of an electron crossing the threshold determined by r_0 and entering the curved space-time region determined by λ_{ce} - λ_{cp}. In such a case there will be a possibility the electron to fall into one of the energy holes of the curved space-time. Hydrogen atom with an electron in such a position will exhibit some exotic properties and certainly will be an unstable system. Being an unstable system such an atom will eject the electron. This electron will have an energy of an order of MeV, corresponding to the energy hole of the curved space-time, from which the electron was ejected. An electron can have such an amount of energy only if it moves with superluminal velocity [5]. This electron will produce an electromagnetic field, which corresponds to the energy of the electron.

The discribed process of proton-electron interaction in the curved space-time, is in fact interactrion between their masses, but the outcome of that interaction is the production of the electromagnetic field. This hypothetical process shows a direct connection between the phenomena covered by the Theory of General Relativity and electrodynamics phenomena.

The results of the presented analysis could be considered as an explanation of the observed results in the Shoulders' experiments with charge clusters [16], [17]. In these experiments, electrons with high energy are detected, and photons in the visible and higher energy regions are observed. These results cannot be explained with current theories. If the connection between the presented analysis and the Shoulders' experiments is established, then these experiments could be considered as a verification of the here explained possibility for extraction of the energy from curved space-time vacuum. In such case, **the devices by which Shoulders' experiments are performed are in fact technical systems where extraction of energy from vacuum is practically accomplished.** The analysis which would connect the presented theory and the Shoulders' experiments will give a solid ground for designing new energy sources.

4. EXPERIMENTAL VERIFICATION OF THE OBTAINED RESULTS

The verification of the obtained results by the analysis can be achieved in here proposed experimental set up.

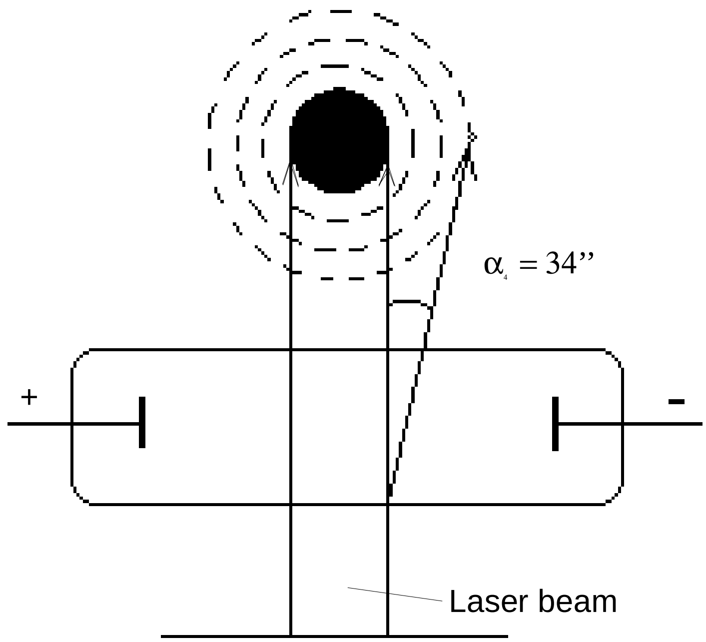


Fig. 8 Experimental set up for observation of light's deflection as a result of space-time curvature around the protons in a tube with ionized hydrogen.

When the laser beam passes through the ionized hydrogen, dispersion of the light as a result of photon-proton interactions should be expected. If the side effects on the glass walls of the tube are excluded, then on the screen, where the laser beam ends, an image presented on the Fig. 6 should be expected. The Fig. 6 shows that around the brightest spot of the laser beam, there should be circles as a result of interference of dispersed light. If this dispersion is a result of deflection of the light passing near the protons, then an angle

$$\alpha \approx 34''$$

should be observed between the fringe of the laser beam and the fringe of the image as Fig. 6 shows. In order to obtain the image, where this small angle can be measured, it is necessary to put the screen on the longer distance from the tube (about 10 m).

The above description of the experiment should be considered only as an ideal case. Actually, certain technical problems should be solved in order a successful experiment to be performed. First of all, it can not be expected distinctive interference image to be observed. The main reason for this is insufficient proton density in the tube, and consequently the restricted number of photon-proton interactions, which are expected to deflect the laser beam. The other problem will be caused by the fact that besides the laser beam, there is another light source, i.e., the gas tube. Hence, the standard methods of screening and filtering will not be of much help, because of introducing side effects, as are, diffraction and absorption of deflected photons.

Despite the first impression that the experiment is very simple, it is actually a search for **individual** photons, which have to be detected on certain spots between the fringe of the laser beam and the fringe, which corresponds to the angle $\alpha = 34''$, what certainly is not an easy task.

More complex experiments with heavier nuclei and crystals should be considered as more reliable. If photons were detected in the experiments within the angles α_5 and α_6, which correspond to the region beneath the *particle surface*, then it would be new method for exploring the nature of nucleon's structure. Besides the visible spectrum of light, X and gamma rays can be employed in the experiments.

If the results of the presented theory and analysis were experimentally verified then it would be an additional proof that the valid concepts of nuclear forces should be reconsidered. A promising approach for that is presented in the Ref.[5].

5. THE OTHER CONSEQUENCES OF INTRODUCING G'$_{\mathbf{n}}$

In the presented analysis by substituting G with G'$_{\mathbf{n}}$ in the Einstein's equation for angle of light's deflection near Sun, it was shown that same equation could be used for nucleons. The obtained results indicate the possibility for existence of space-time curvature around proton.

The other, even more basic equation, where this kind of modification can be done, is Newton's law of gravity. For the particles with masses m_1 and m_2, separated by a distance r, the magnitude of the gravitational force between these two particles is,

$$F_g = G\frac{m_1 m_2}{r} \tag{39}$$

In the Ref.[5], G is substituted by G'$_{\mathbf{n}}$ and gravitational force between the particles in the proton-neutron system is,

$$F'_g = G'_n \frac{m_p m_n}{r} \tag{40}$$

This assumption leads to a new comprehension of nuclear forces, because F'_g can not be neglected, on the contrary, it has considerable value.

The main experimental verification of the principles of the Theory of Superluminal Relativity is the magnetic moment of deuteron nucleus. The accordance between experimentally observed value, and computed value by this theory is 0,001%.

The other experiment where the principles of the Theory of Superluminal Relativity are employed in Ref.[5] is proton-neutron scattering. It has been shown that Coulomb's law for electric force between the charges,

$$F_e = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r} \qquad (41)$$

is valid for nuclear structures, as well. However, the results of the analysis indicate the necessity the constant,

$$\varepsilon_0 = 8.854 \cdot 10^{-12}\ \mathrm{C^{-2}Nm^2} \qquad (42)$$

to be taken valid, only for macroscopic systems. For nuclear systems the magnitude ε'_0 should be introduced as a magnitude, which expresses the vacuum structure connected with charge, and consequently to have different values in different systems. Hence, for nuclear structures the Eq.(39) becomes,

$$F'_e = \frac{1}{4\pi\varepsilon'_0}\frac{|q_1||q_2|}{r} \qquad (43)$$

In Ref[5], the magnitude ε'_0 for nuclear structures has been neither defined nor determined. However, it is justified to assume that it can be achieved by applying O(3) Electrodynamics Theory [18].

6. ON GRAVITY A

There is a concept that gravity in general consists of two types of gravity: B, gravity in macroscopic world and A, gravity in microscopic world that is in nucleon's and atomic scale. If this concept is accepted, then there must be magnitudes, which determine these two types of gravity and correlation, which connect them.

By this approach space-time curvature caused by the density of the nucleons, what is called Gravity A, is merely Gravity B on the micro scale. When one looks at the densities and the short distances involved, Gravity B is very important in determining the space-time curvature around nucleons. However, the space-time curvature of a nucleon is effected by other nucleons and their vibration to produce a composite space-time curvature, or shell that binds them together in a low energy state. It is possible to think of this as being at the bottom of a pit, where looking in any outward direction up hill will be seen, requiring more energy. It is justified to believe that space-time curvature waves emanating from the vibrating space-time curvature shell around the nucleus along with coulomb forces determine the quantum energy states for the electrons surrounding a nucleus. These effects are very short range, a few fm, as the gravity is small and these forces arise from the energy density with respect to the short radius. To use energy density as equivalent to mass density is more convenient, because even though it is conceivable that large nuclear structures could offer access to a large degree of space-time curvature.

By the other approach, applied in the analysis presented in this paper, there is correlation by the gravitational constant G' with gravitational magnitude G_n'. This correlation is achieved by the constant K_α. The outcome of this analysis is space-time curvature around nucleons.

Figs. 6 and 7 show that gravitational field around nucleons in this case, around proton, has periodic nature. Because any nucleon is in constant motion, linear circular or vibrational, it is obvious that this gravitational field will produce corresponding gravitational waves. In Ref. [5] it is shown that nucleons during their circular motion in the deuteron nucleus emit binding particles (pions or muons). This is the result of the nucleons' motion in the gravitational field with periodic nature caused by the space-time curvature around the nucleons.

Correlation between these two approaches for determining the existence of space-time curvature in nucleon and atomic scale, will be shown here.

The first approach assumes that Gravity A can be expressed by Gravity B, that is, when gravitational magnitude G'_n is expressed by the gravitational constant G. In the second approach the gravitational magnitude G'_n is expressed by G', which is defined and determined by the Eq. (12).

Empirically obtained expression shows that,

$$G' = \frac{G}{K_g} \qquad (44)$$

where,

$$K_g = \alpha^8 \left(\frac{\lambda_{cp}}{\lambda_{ce}} \right)^5 \cdot 10^{-3} \tag{45}$$

All three magnitudes, which appear here, λ_{cp}, λ_{ce}, and α, actually determine the range, where gravitational field is quantized, by the second approach.

If G' is substituted from Eq. (44) into the Eq. (24) it yealds,

$$G_n' = \frac{G}{K_g (\alpha')^n} \tag{46}$$

The latter equation shows that the gravitational magnitude G_n' for the gravity A now is expressed by gravitational constant G for the Gravity B. The factors K_g and $(\alpha')^n$ express quantum gravity for defined region.

If we substitute the masses with densities in the Eq. (5) and Eq. (27) for the Sun and the proton, respectively the next equations will be obtained,

$$\alpha_s = \frac{4GV_s d_s}{r_s c^2} \tag{47}$$

and

$$\alpha_k = \frac{4G_n' V_p d_p}{r_k c^2} \tag{48}$$

where V_s and V_p are the Sun's and proton's volumes, respectively.

The ratio of these two angles yealds,

$$\frac{\alpha_k}{\alpha_s} = \frac{G_n'}{G} \frac{V_p d_p r_s}{V_s d_s r_k} \tag{49}$$

where,

$$\frac{G_n'}{G} = \frac{1}{K_g (\alpha')^n} \tag{50}$$

then Eq.(49) becomes,

$$\frac{\alpha_k}{\alpha_s} = \frac{1}{K_g (\alpha')^n} \frac{V_p d_p r_s}{V_s d_s r_k} \tag{51}$$

If we introduce the constant,

$$K_v = \frac{1}{K_g(\alpha')^n}\frac{V_p}{V_s} \tag{52}$$

then the Eq. (51) gets the final form,

$$\frac{\alpha_k}{\alpha_s} = K_v \frac{d_p r_s}{d_s r_k} \tag{53}$$

the latter equation shows that the ratio of the angles of deflections α_k and α_s of the lights passing near the proton and the Sun, respectivelly is directly proportional to the ratio of the densities d_p and d_s for proton and Sun respectivelly, and to the ration of r_s and r_k, the shortest distancies of the lights' paths to the centers of the Sun and the proton, respectivelly.

The Eqns. (38), (53) evidently show that the two approaches mentioned above for determining the space-time curvature in nucleon and atomic scale are compatible.

7. CONCLUSIONS

The results of the analysis presented here show that the Theory of General Relativity should be considered as an Universal Theory of Gravitation, which is valid not only for cosmic objects and distances, that is for cosmic systems, but also for nuclear particles and distances i.e., for nuclear structures. Consequently, the gravitational constant G should be considered as a constant only for macroscopic world, but its universal meaning is that it is a magnitude, which expresses the structure of the vacuum connected with gravitational properties of the bodies, in general. For vacuum structure determined by the nucleons, and nuclear structures, gravitational constant is turning into gravitational magnitude $G'_{\mathbf{n}}$, which is determined by the quantum number n, for distances in the range λ_{ce} - λ_{cp}. Gravitational magnitude G'_n is defined and determined by the principles of the Theory of Superluminal Relativity. The relation between the angles of deflections of the lights, passing near the Sun and near the proton and their masses is established in the presented analysis. This relation shows the existence of the space-time curvature around the proton. Hence, the observed angle of the light's deflection during the eclipse of the Sun should be considered as a verification of the supposition that the Theory of General Relativity is equally valid for nuclear systems as for cosmic systems.

The positions of proton and neutron, which create deuteron nucleus are determined, furthermore, the binding energy of this nucleus is determined, by the computation where magnitudes, which determine space-time curvature around proton are used.

Because all of this is achieved by the principles of the theory of Superluminal Relativity, the obtained results could be considered as an additional verification of these principles and applied theory.

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